The Animal Stress Detector

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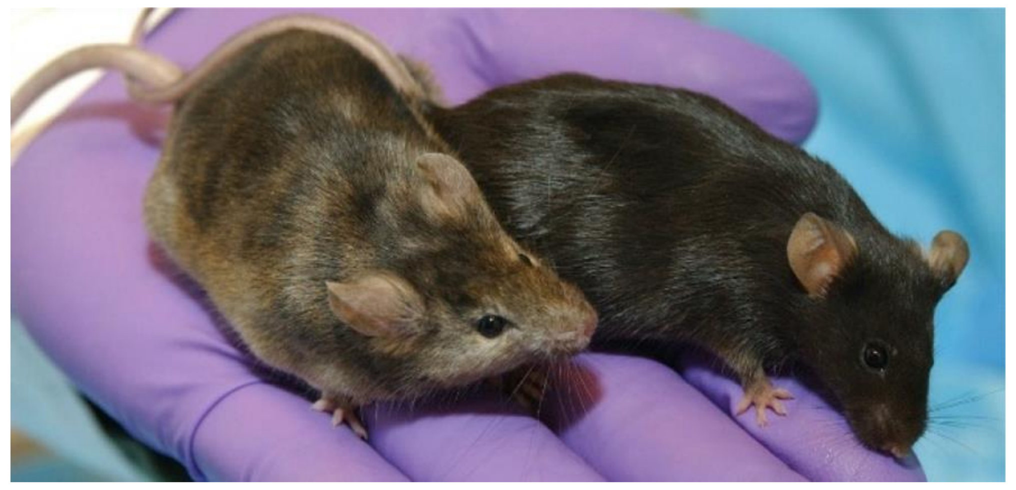
Background

- Mice are commonly used in research to study models of human disease and develop therapies [1]
- To create convincing experiments, all variables including the animal's physiological state must be as controlled as possible
- Current stress monitoring techniques:
  - **Behavioral testing –** time and labor intensive, subject to varied interpretation
  - **Blood draws –** induce stress, not continuous
  - **Saliva swabs –** invasive, not continuous



Approach

Brainstormed three potential solutions

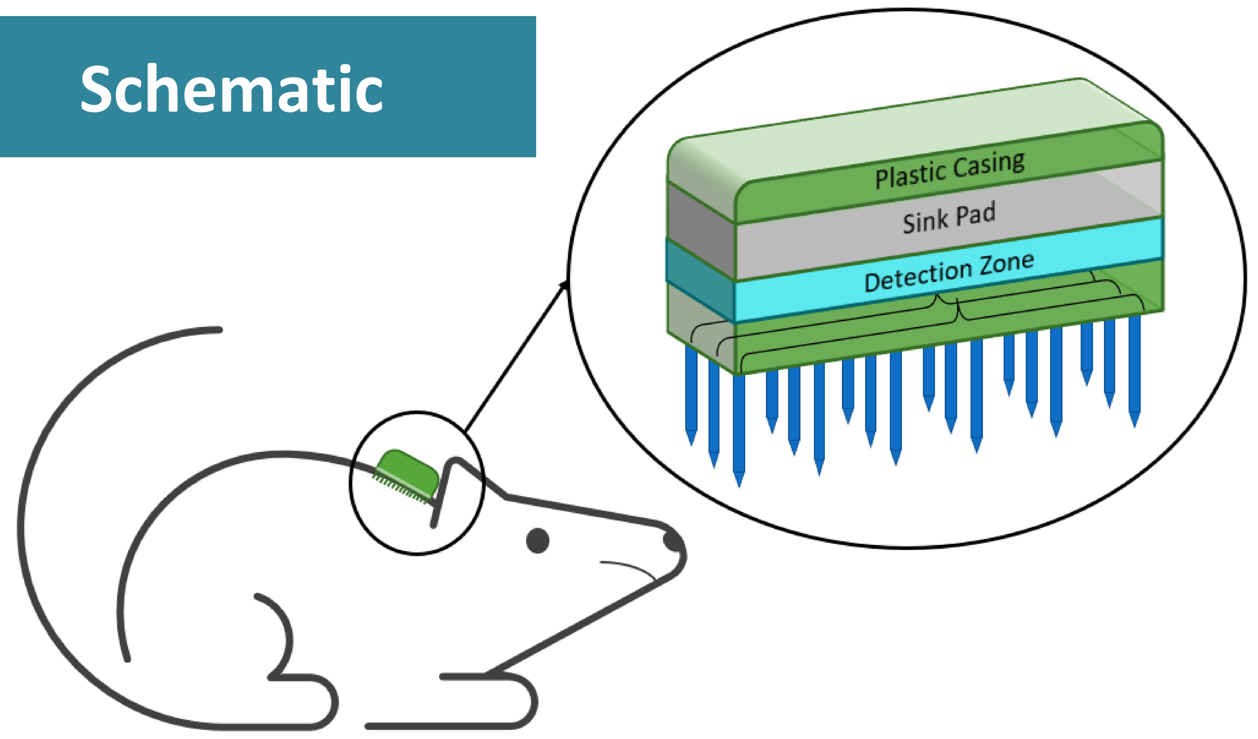
- Tooth chip sensor to measure cortisol in saliva
- Implanted blood cortisol detection device
- Wearable interstitial fluid (ISF) monitor **– Most feasible!**

Performed a literature review

- Reviewed 20+ articles related to microfluidic and microneedle devices, electrochemical assays, ISF extraction, continuous detection assays, etc.
- Used research to inform the development of initial models

Developed mathematical and physical models of the device

Schematic



Problem: No empirical method of assessing an animal's relative stress or pain

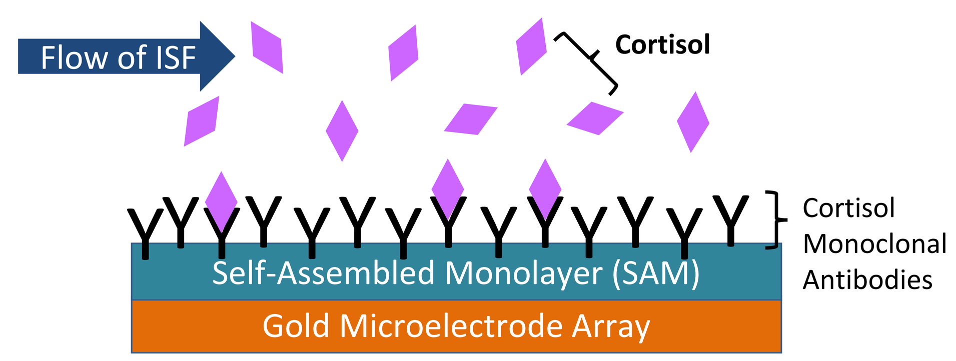
Goal: Design a device that can **noninvasively** and **continuously** monitor stress levels in animals

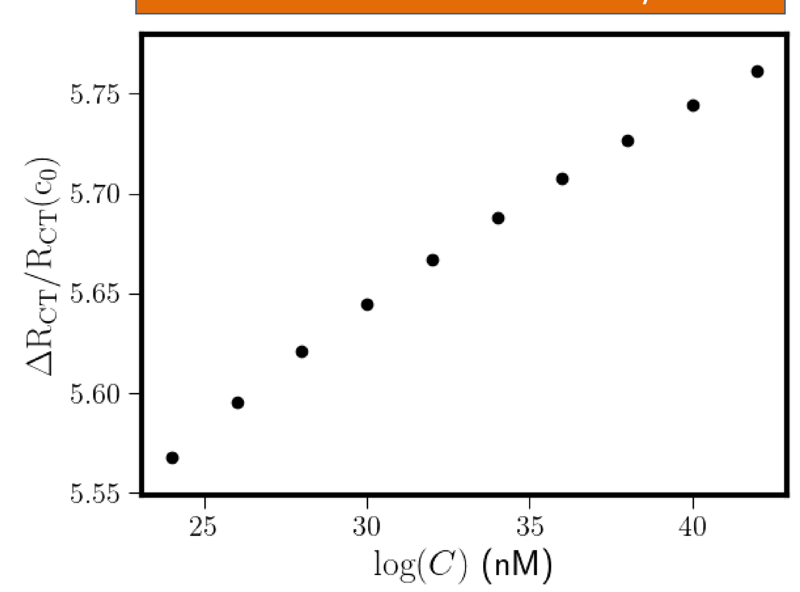
Our Solution: A wearable microfluidic monitor that utilizes an electrochemical assay to measure cortisol levels

Modelling the Device

Cortisol Detection

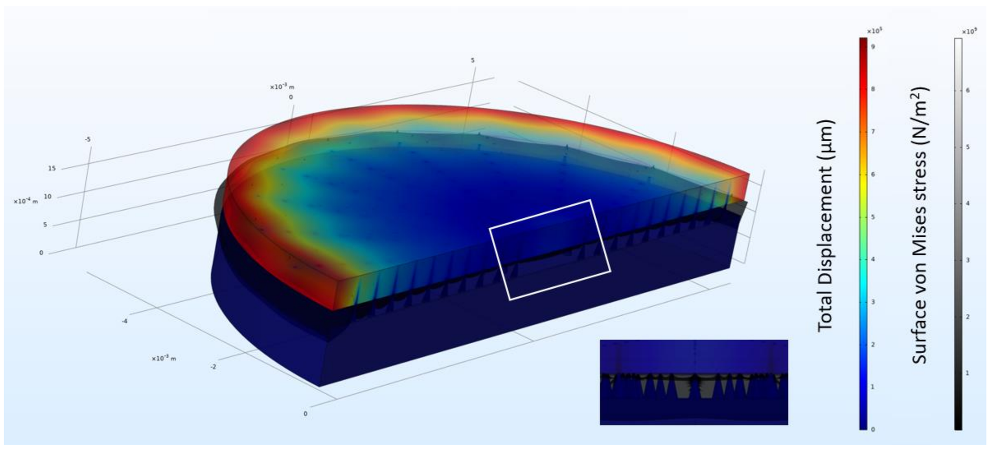
- Electrochemical Impedance Assay
- Cortisol binds to antibodies on the surface of a microelectrode
- Resistance changes proportionally to concentration of cortisol [2]





Microneedle Array

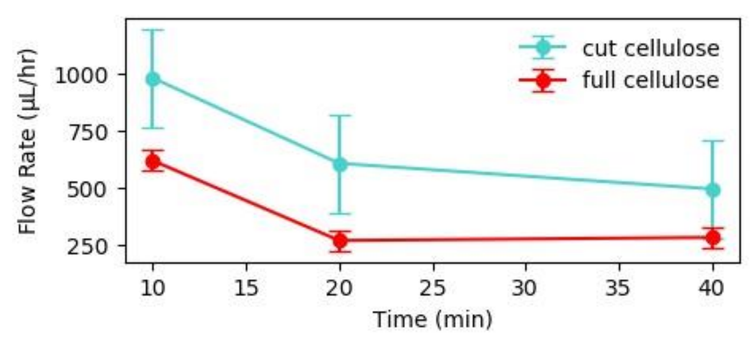
- 200 microneedles needed to have good adhesion
- Analysis of surface stress and piercing force was used to determine material for needles – silicon carbide
- Radial design to allow for equal distance fluid transfer into detection zone
- COMSOL model shows that the needles withstand force needed to pierce skin



Capillary Driven Flow

- Washburn equation used to model flow
- Scaled-up flow rate was calculated for 2 models shown on the left and right

Whatman cellulose cut channels



Hydrophobic wax printed channels

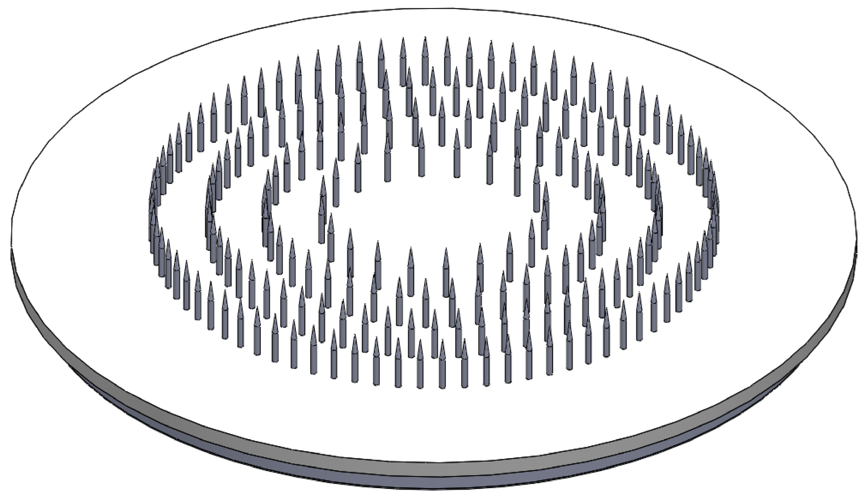
Physical Prototype

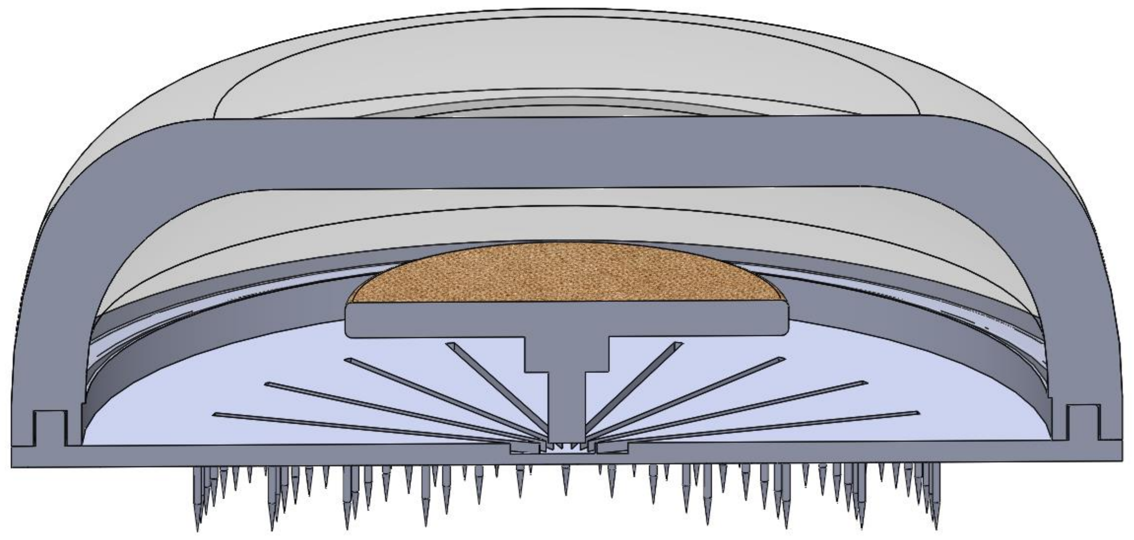
Features

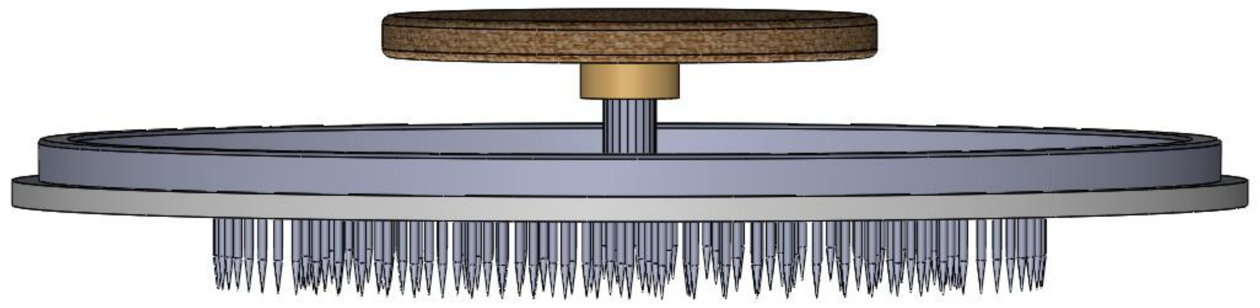
- Smooth round surfaces to minimize irritation
- Medical grade adhesive surrounding microneedles
- 3D printed prototype is scaled up 10x

Dimensions

- 1.5cm diameter
- 0.5 cm tall







References

[1] https://theconversation.com/animals-in-research-mice-14172

[2] S. K. Arya, G. Chornokur, M. Venugopal, and S. Bhansali, "Dithiobis(succinimidyl propionate) modified gold microarray electrode based electrochemical immunosensor for ultrasensitive detection of cortisol," *Biosensors and Bioelectronics*, vol. 25, no. 10, pp. 2296–2301, 2010.

Acknowledgements

We would like to thank Dr. Higgins and Dr. Geoghagen for their support and guidance. We would also like to thank the Fu Lab for their feedback and assistance in developing our prototype, specifically Corey Downs for the fabrication of the microfluidic channels. Finally, we would like to thank our TA Ramila for performing the first round of flow testing.